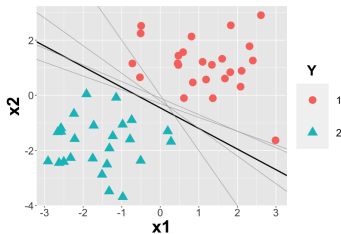


Introduction to Machine Learning

ML-Basics In a Nutshell



Learning goals

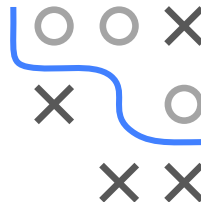
- Understand fundamental goal of supervised machine learning
- Know concepts of task, model, parameter, learner, loss function, and empirical risk minimization

WHAT IS ML?

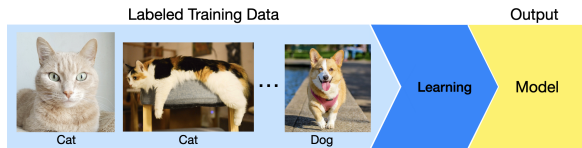
“A computer program is said to learn from experience E with respect to some task T and some performance measure P , if its performance on T , as measured by P , improves with experience E .”

Tom Mitchell, Carnegie Mellon University, 1998

⇒ 99 % of this lecture is about **supervised learning**:



Training



Prediction

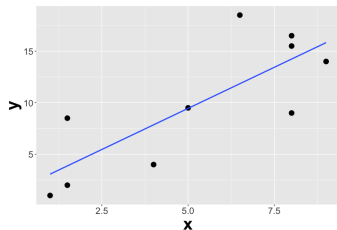


TASKS

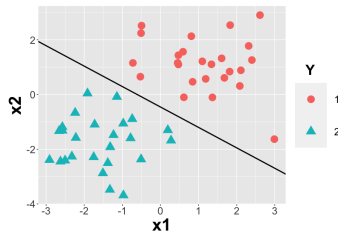
- Supervised tasks are labeled data situations where the goal is to learn the functional relationship between inputs (features) and output (target)
- We distinguish between **regression** and **classification** tasks, depending on whether the target is **numerical** or **categorical**



Regression: Target is **numerical**, e.g., predict days a patient has to stay in hospital

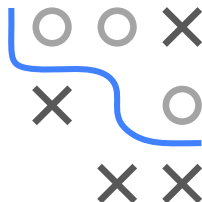
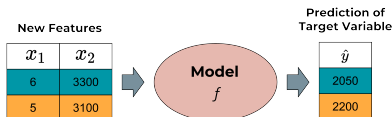


Classification: Target is **categorical**, e.g., predict one of two risk categories for a life insurance customer



MODELS AND PARAMETERS

- A model is a function that maps features to predicted targets



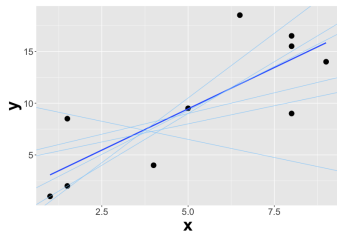
- For finding the model that describes the relation between features and target best, one needs to restrict the set of all possible functions
- This restricted set of functions is called **hypothesis space**. E.g., one could consider only simple linear functions as hypothesis space
- Functions are fully determined by parameters. E.g., in the case of linear functions, $y = \theta_0 + \theta_1 x$, the parameters θ_0 (intercept) and θ_1 (slope) determine the relationship between y and x
- Finding the optimal model means finding the optimal set of parameters

LEARNER

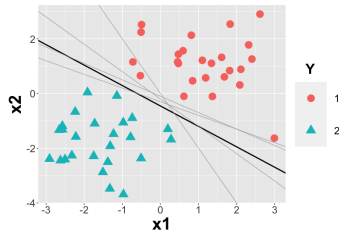
- Learns automatically the relation between features and target – given a set of training data
- Learner picks the best element of the **hypothesis space**, i.e., the function that fits the training data best



Regression:

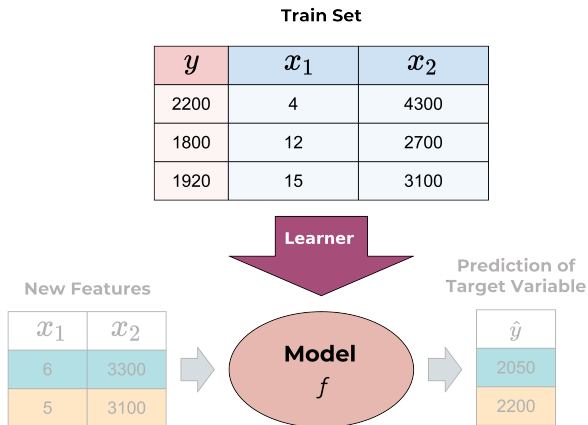
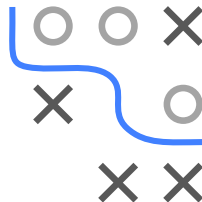


Classification:



LEARNER / 2

- Learner uses labeled training data to learn a model f . This model is applied to new data for predicting the target variable



A 3x3 grid with a blue path starting at the top-left cell (0,0) and ending at the bottom-right cell (2,2). The path consists of the following cells: (0,0), (0,1), (1,1), (1,2), and (2,2). The cells (0,2), (1,0), and (2,0) are empty. The cells (1,0) and (2,0) contain a black 'X'. The cells (0,1) and (1,1) contain a grey circle. The cell (2,1) contains a grey circle.

- $$L(y, f(\mathbf{x})) = (y - f(\mathbf{x}))^2$$

- $$\mathcal{R}_{\text{emp}}(f) = \sum_{i=1}^n L(y^{(i)}, f(\mathbf{x}^{(i)}))$$

A scatter plot illustrating a linear regression model. The x-axis is labeled 'x' and ranges from 0.0 to 10.0. The y-axis is labeled 'y' and ranges from 0 to 20. A blue line represents the fitted regression model. A light blue shaded rectangular region is shown, representing the prediction interval for a specific value of x. The text $L(y, f(4)) = (4 - 7.86)^2 = 14.87$ is displayed near the shaded region, indicating the squared residual for the point at x = 4.

EMPIRICAL RISK MINIMIZATION

- The risk surface visualizes the empirical risk for all possible parameter values of the parameter vector θ
- Minimizing the empirical risk is usually done by numerical optimization

$$\hat{\theta} = \arg \min_{\theta \in \Theta} \mathcal{R}_{\text{emp}}(\theta).$$

